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‘Denita’s Autumn Sunshine’: A Cultivar of the Endangered Sunflower *Helianthus verticillatus*

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There are more than 50 wild *Helianthus* species (Schilling 2006; Seiler et al. 2018) of which, *H. verticillatus* Small, the whorled sunflower, is a perennial species and was listed as critically endangered in 2014 (US Fish and Wildlife Service 2014). The whorled sunflower has very limited distribution in the southeastern United States and is restricted to a few locations in Tennessee, Alabama, Virginia, Georgia, and Mississippi (Mandel 2010; Moore et al. 2022). A method to conserve rare, self-incompatible plants is to establish gardens or plots with a wide assortment of compatible genotypes to facilitate seed production. We have established such plots at the University of Tennessee Forest Research Center (University of Tennessee Arboretum) Oak Ridge, TN, USA; the University of Florida at Gainesville, USA; and at a residential area in Maryville, TN, USA (Trigiano et al. 2021). The plants in these plots produced a copious number of seeds, most of which were viable (Trigiano et al. 2021). However, a problem of seed production of *H. verticillatus*, especially in residential areas, was the unintentional distribution of seeds, probably by small birds and mammals, and the unwanted establishment (weediness) of new plants throughout the area.

Reproduction by compatible genotypes and seeds does offer a partial solution for conservation of *H. verticillatus* but is impractical for homeowners. To provide this sunflower species to the general public, it was first necessary to develop a fast and easy method of clonal production of the self-incompatible genotypes. A reliable way to produce clonal plants is by rooted cuttings (Trigiano et al. 2021). Herein, we describe the seasonal growth and physical characteristics of ‘Denita’s Autumn Sunshine’, a self-incompatible, clonally produced cultivar of *H. verticillatus*.

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Materials and Methods

Specimen plants from West Tennessee (Madison County) were collected before this species classification as endangered in 2014. Individual plants were grown on the University of Tennessee Knoxville campus and eventually at the University of Tennessee Forest Research Center (University of Tennessee Arboretum) Oak Ridge, TN, USA, and several home gardens in Maryville and Knoxville, TN, USA. ‘Denita’s Autumn Sunshine’ was selected as a vigorous grower with a stout (thick) stems that do not lodge in windy locations, and flowered profusely. It is the source plant for plantings at three home evaluation locations in Knoxville. ‘Denita’s Autumn Sunshine’ was propagated asexually by stem cuttings harvested in May and June of multiple years, which were rooted under intermittent mist and 50% shadecloth in a greenhouse (Trigiano et al. 2021). Various *H. verticillatus* genotypes may also be propagated clonally by in vitro techniques of axillary bud proliferation (Nowakowska et al. 2020). No attempt was made to propagate ‘Denita’s Autumn Sunshine’ using tissue culture techniques.

Plants were established at three locations in Knoxville in 2019, and these locations were 5 to 15 miles from each other. Each location had between 40 and 70 stems. After inflorescences turned brown in mid–late October, they were bagged with pollination shoot bags (Midco Global, Town and Country, MO, USA) and seed production was assessed in November in each of the 3 years. Viable seeds were never produced and supported the finding of self-incompatibility of *H. verticillatus* in general (Mandel 2010) and specifically for ‘Denita’s Autumn Sunshine’.

Results

Seasonal growth and propagation of ‘Denita’s Autumn Sunshine’. Multiple stems with juvenile ovate- or round-shaped leaves of ‘Denita’s Autumn Sunshine’ emerged from underground,

Fig. 1. *Helianthus verticillatus* ‘Denita’s Autumn Sunshine’. (**A**) Whorls of leaves on short stems emerging from rhizomes in late February and early March (Knoxville, TN, USA). (**B**) Multiple stems ~2 to 3 ft tall in late April.

Fig. 2. (**A**) *Helianthus verticillatus.* Multiple stems of ‘Denita’s Autumn Sunshine’ in late May (Knoxville, TN, USA) that were used for propagation (rooted cuttings). (**B**) Numerous adventitious roots formed from two nodes covered with medium. The shoot portion has also grown during the 6 to 8 weeks under mist. See Trigiano et al. (2021) for details.

locally invasive rhizomes in late February or early March in Knoxville, TN, USA (Fig. 1A). Stems grew slowly and reached a height of 2 ft (0.6 m) by late April (Fig. 1B). Leaves of 'Denita's Autumn Sunshine', which are formed subsequently, were small and lanceolate-shaped, a characteristic of 'Denita's Autumn Sunshine' (Fig. 1B). Individual stems continue to grow and reached a height of ~3 to 4 ft (0.9–1.2 m) in late May (Fig. 2A). Typically, two node stem segments can be harvested for rooted cutting propagation at this time (Trigiano et al. 2021). Stem cuttings root quickly under intermittent mist, and extensive adventitious roots are formed within 6 to 8 weeks (Fig. 2B). The cut ends of the harvested stems on plants soon became dry and white (Fig. 3A) and axillary buds (released from apical dominance) in each of the subtending nodes began to elongate (Fig. 3A). At the end of June, the newly formed stems (Fig. 3B) may be harvested for rooted cuttings under the same conditions described previously. Typically, four to six rooted cuttings from one plant can be made from harvested stems sections in May and June.

H. verticillatus, including 'Denita's Autumn Sunshine', tolerates hot, dry environments in Tennessee landscapes, and although plants often wilt during a hot, dry day (Fig. 4A), they recovered full turgidity during the night (Fig. 4B). In late July and early August, the apical bud of the multiple stems converted to a large flower bud (Fig. 5A). With the loss of apical dominance, the axillary buds subtending the apex elongated (Fig. 5B), and within 10 d, the apical meristem of the newly elongated stems produced flower buds (Fig. 5C). Flowering typically began with the apical flower bud opening during the last week of September or the first week of October in Tennessee, and most flowers on the subtending branches opened within the first 10 d of October. This created a beautiful "spray of yellow flowers" that lasted until the first hard frost or until the end of October (Fig. 6A). A list of physical attributes of 'Denita's Autumn Sunshine' is provided in Table 1. The open flowers attracted more than 40 potential pollinators, many of which are native bees and butterflies (Strange et al. 2020) that added interest to the whorled sunflower as a garden plant (Fig. 6B and C). Viable seeds have never been produced at the three locations where only 'Denita's Autumn Sunshine' was grown, confirming that this variety is self-incompatible.

Diseases of the whorled sunflower. The leaves of 'Denita's Autumn Sunshine' were infected by an array of fungi that incited minor cosmetic spots or necrotic areas (e.g., Boggess et al. 2022; Edwards et al. 2017; Odoi et al. 2022; Trigiano et al. 2020), but these apparently did not influence the growth of the plant, nor did they interfere with flowering. Two common and prevalent diseases of 'Denita's Autumn Sunshine' that typically develop late in the growing season are powdery mildew caused by *Golovinomyces ambrosae* (Trigiano et al. 2016) and a rust incited by *Coleosporium helianthi* (Trigiano et al. 2022). Powdery mildew manifested as white mycelium and conidia on the upper surface of the leaves (Fig. 5C) and did not appreciably affect the growth or flowering of 'Denita's Autumn Sunshine' but did negatively affect the aesthetic value of the plants. The rust occurred only on 'Denita's Autumn Sunshine' grown under or near various *Pinus* species. The disease first appears as

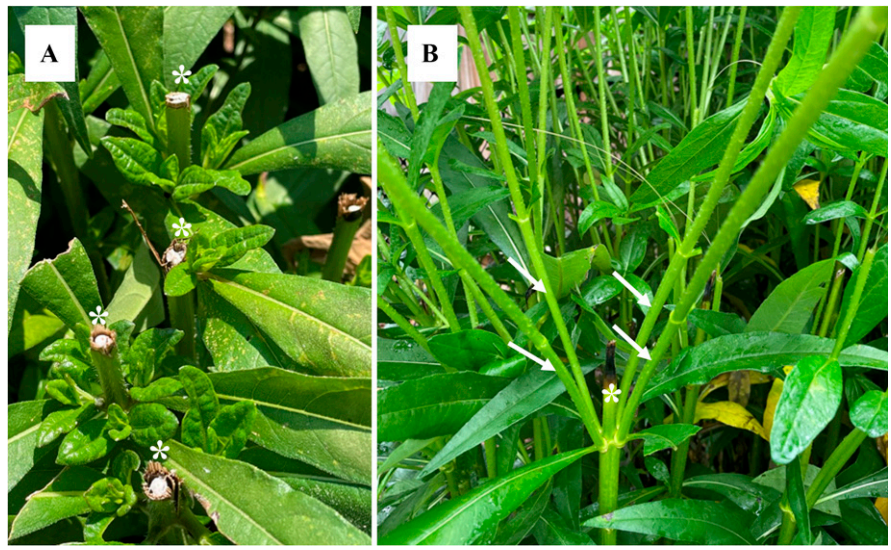

Fig. 3. *Helianthus verticillatus* 'Denita's Autumn Sunshine'. (**A**) Axillary budbreak in the first week of June ~10 d after making cuttings for rooting. White asterisks indicate previously cut stems. (**B**) Four shoots (white arrows) originating from axillary buds in the third week of June. White asterisk indicates previously cut stem.

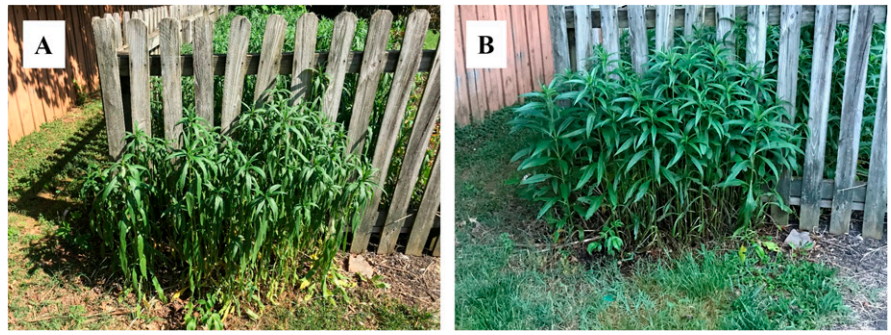

Fig. 4. *Helianthus verticillatus*. (**A**) Wilted leaves and stems in the late afternoon (5:00 PM) in June (Maryville, TN, USA). (**B**) Fully turgid leaves and stems the following morning (8:00 AM). Color differences in the plants are due to changes in ambient light at the two times mentioned.

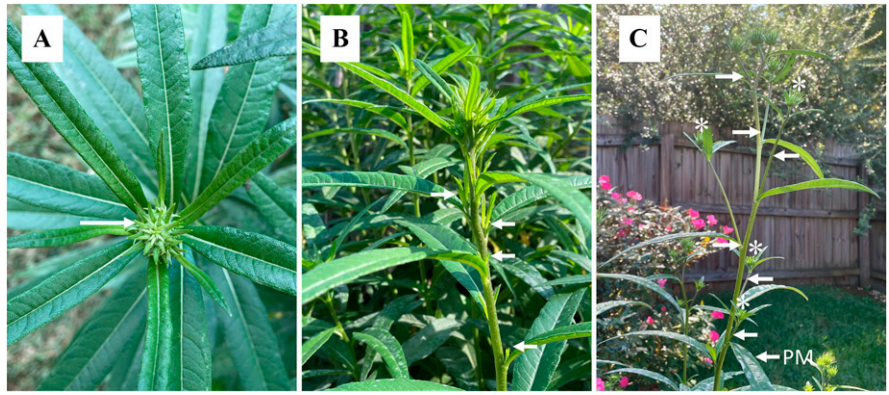

Fig. 5. *Helianthus verticillatus* 'Denita's Autumn Sunshine'. (**A**) Top view of the terminal apical bud converted into the "King" (inflorescence) flower bud (arrow) in late July and early August. (**B**) The internodes and the axillary buds (arrows) of the leaves begin to elongate with the loss of apical dominance (~1st or 2nd week of August). (**C**) Axillary buds have elongated (arrows) by the third and fourth weeks of August. One terminal flower bud (asterisks) has formed in addition to three or four lateral flower buds on each new stem. Powdery mildew (PM) is evident on older leaves below the level of flower buds. Note that the dates provided in the figures can vary by location and year.

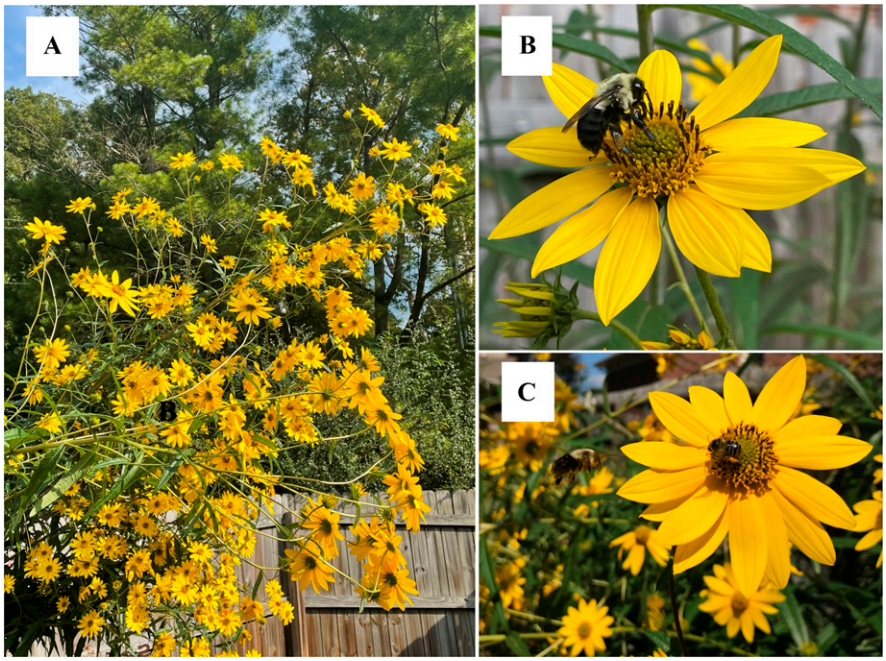

Fig. 6. *Helianthus verticillatus* 'Denita's Autumn Sunshine' in early October. (**A**) In full bloom with a multitude of inflorescences (fence in background is 6 ft high). Untrimmed sunflower stems can grow to 12 to 14 ft (~4 m) tall, whereas those cut for rooted cuttings or trimmed in the Spring are typically 5 to 7 ft (2 m) in length. (**B** and **C**) Individual inflorescences visited by native potential pollinators.

"white stippling" on the upper leaf surface and subsequently on the lower leaf surface as yellow/orange uredial pustules, which later converted to rust-brown-colored telia (Trigiano et al. 2022). This disease, like powdery mildew, only has a cosmetic effect on the plants.

Availability

For additional information and availability contact R. N. Trigiano at rtrigian@utk.edu.

Table 1. Physical characteristics of inflorescences, leaves and stems of *Helianthus verticillatus* 'Denita's Autumn Sunshine' in September.

	Range	Mean[i]	Color[ii]
Flower characteristics			
Number of flower heads (inflorescences)/plant	25–43	33	
Number of ray florets/inflorescence	14–17	15	12A yellow group
Number of disc flowers/inflorescence	84–132	109	21B yellow-orange group
Disc flowers mound above receptacle (mm)	19–26	22	
Length (mm) of ray florets "petals"	17–36	25	
Width of ray floret "petals" (mm)	9–13	11	
Number of bracts/receptacle	22–34	29	
Length (mm) of inflorescence pedicle	45–142	74	
Leaf characteristics			
Leaf width (mm)	24–36	32	
Mid-vein (mm)	3–5	4	194B gray-green group
Semi-clasping petiole	—	—	
Number of bracts	4–6	5	137A:B green group
Stem characteristics			
Diameter of stem (cm)	1.5–2.4	2.1	
Internode length (mm)	40–55	46	
Internode length (mm)	50–74	67	
First flower branch from apex of plant (cm)	13–52	37	

[i] Mean of a minimum of 15 samples.
[ii] Colors according to the Royal Horticultural Society (RHS) Colour Chart (2001).

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